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ABSTRACT

Measures of income and salary inequality used by economists were examined and applied against 1984-1985 faculty salary data. Attention was directed to salary inequality at each academic rank, as well as female-male inequality. The following measures were used: Lorenz Curve-Gini Coefficient, coefficient of variation, Theil's Index, and Atkinson's Index, an inequality measure proposed by Gastwirth (the PROB measure), and the Differences in Cumulative Percentatges measure. Using salary survey data from 23 midwestern universities, average salaries for 53 disciplines were examined at the ranks of full, associate, and assistant professor. Data were obtained from 159 average salaries and 12,420 individual faculty salaries, or 92% of the total faculty sample. Findings include: in terms of absolute values, the measures indicate the following: faculty salary inequality is very low; salary inequality is highest for assistant professors and lowest for full professors; salary inequality between female and male faculty is lowest for assistant professors and highest for full professors; and salary inequality between female and male faculty is about the same as female-male inequaltiy in all other occupations. (SW)

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# Measures of Salary Inequality

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Abstract

Comprehensive measures of salary inequality are needed to measure inequality among all faculty and inequality between faculty groups. Issues such as salary adjustments for market sensitive disciplines and female-male salary inequality necessitate the annual assessment of salary inequality. This paper examines measures of income and salary inequality traditionally used by economists, and applies these measures against faculty salary survey data. Salary inequality at each professorial rank is analyzed, and female-male inequality also is measured.

Salary inequality necessarily exists among faculty due to differences in academic discipline, rank, experience and performance. Also, the degree of salary inequality can change because of faculty turnover, promotions and changing market conditions. Therefore, salary inequality is expected and, except for instances of discrimination, inequality does not indicate inequity or unfairness. A high degree of salary inequality may even indicate faculty quality is relatively high (Adams & Krislov, 1978).

Although inequality may be an accepted fact, the higher education community is presently concerned about two aspects of salary inequality. One concern is the inequality from relatively higher salaries being paid to faculty in market sensitive disciplines. As the salaries of business and engineering faculty rise relative to the salaries of other faculty, budgets become tighter and faculty discontent increases (Prokasy, 1984). The other concern is the salary inequality between faculty groups, especially between female and male faculty, and between racial minority and non-minority faculty. The impact of discrimination on salary inequality is a much debated issue, but discrimination per se is not discussed in this paper. It is assumed, however, that at least some percentage of the observed inequality is due to discrimination, but the exact percentage would depend upon one's definition of discrimination.

Researchers need descriptive measures of inequality not only based on means or averages, but also based on the dispersion of salaries around the mean. Economists traditionally have used such comprehensive measures to quantify income inequality within countries and to make comparisons among countries. This paper examines the major inequality indices used by economists, and applies these measures against 1984-85 faculty salary survey data. Inequality at each rank is analyzed, and a salary

redistribution experiment is conducted to demonstrate the sensitivities of the measures. The indices are most useful for "tracking" an institution's salary inequality over time. Of course, the measures by themselves provide no information on "why" salary inequality has changed, or determine the amount of inequality which "should" exist for an institution. The indices also can be used for making comparisons between institutions or between professions, but such comparisons can be ambiguous because of interpretation problems.

Measures for describing inequality among all faculty are discussed first, and then applied to survey data. Measures for quantifying inequality between groups are discussed in the latter part of the paper.

## Salary Inequality - All Faculty

### Inequality Measures

Economists have used several measures of income inequality but four measures are used most extensively, (Cowell, 1977; Osberg, 1984, Chap. 2): Lorenz Curve-Gini Coefficient; Coefficient of Variation; Theil's Index; and Atkinson's Index. Each measure is independent of proportional increases in income; i.e., if everyone's income or salary increases by the same percentage, the value of the inequality measure will not change. Further, each measure satisfies the transfer principle by being sensitive to income transfers among different income or salary groups.

Gini Coefficient. The most analyzed and most popular measure is the Gini Coefficient, which is a descriptive index of the Lorenz Curve (Gastwirth, 1972). In Figure 1, the cumulative percentage of wage earners or households (arranged in rank-order from low income to high income) is plotted along the horizontal axis, and the cumulative percentage of total income received by the wage earners is plotted along the vertical axis. If

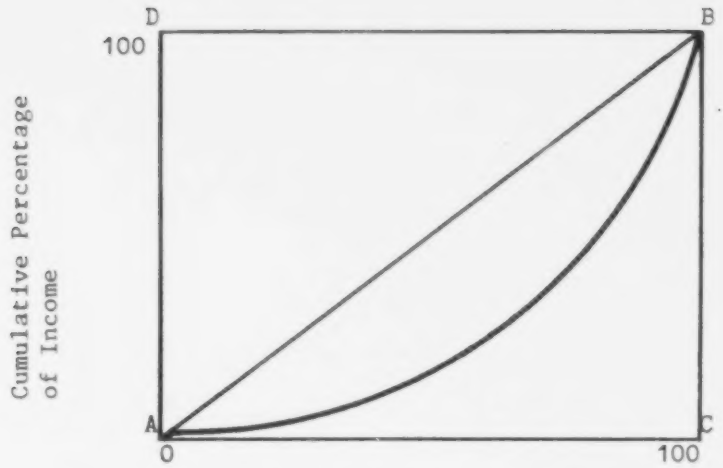


Figure 1. Lorenz Curve-Gini Coefficient

everyone received the same income, the Lorenz Curve would fall on line AB; if "perfect inequality" existed, the curve would lie along ACB. The Gini Coefficient measures the ratio of the area between the Lorenz Curve and line AB to the total area contained in the triangle ABC. Perfect equality yields a Gini Coefficient of zero, while perfect inequality results in a value of one. Of course, the two extremes are never encountered, and most economically developed countries have Gini Coefficients in the range of 0.25 to 0.42 (Osberg, 1984, p. 27).

Interpretation problems can arise with the Gini Coefficient and the other measures when making comparisons over time, or making comparisons between countries or institutions. If one Lorenz curve lies entirely within another, it can be definitely stated that the curve closest to the diagonal line (AB) reflects less inequality. However, if two Lorenz curves intersect, conclusions regarding inequality are somewhat ambiguous, even if the curves have different Gini Coefficients. Firm conclusions can be reached only if "society" can agree on the relative importance of

inequality at different points of the income distribution. For example, society may be more concerned about individuals in the lower half of the income distribution than in the upper half.

Coefficient of Variation. From a statistical perspective, the variance of an income or salary frequency distribution might be considered a possible measure of inequality, but the variance is affected by proportionate increases in income. The variance can be normalized, however, by dividing the square root of the variance (standard deviation) by average income; the resulting measure is referred to as the "Coefficient of Variation." Although both the Coefficient of Variation and Gini Coefficient are sensitive to income transfers, the Gini Coefficient is more sensitive to transfers in the middle income ranges, while the Coefficient of Variation is more sensitive to transfers at the low and high ends of the income distribution. Unlike the Gini Coefficient, the value of the Coefficient of Variation can exceed one.

Theil's Index. The Theil Index is derived from the entropy concept developed in information theory. Essentially, entropy refers to the average information content of a system. There is little information conveyed in a message from a system which is perfectly predictable. However, if the message "surprises" you by providing information you did not know, information has been generated. If income is distributed equally, an individual's income is predictable. However, if income is distributed unequally, income is less predictable, and each individual's income contains information. Theil's Index relies on the ratio of individual income to average income $(y_i/\bar{y})$ and is computed as follows:

$$T.I. = \frac{1}{n} \sum_{i=1}^{n} (y_i/\bar{y}) \log (y_i/\bar{y}).$$

The Theil Index is similar to the Gini Coefficient, as it is more sensitive to movements in the middle part of the income distribution. Also, it has a minimum value of zero, but unlike the Gini Coefficient, its maximum value is unbounded and can exceed one.

The Theil Index has two advantages over the other measures. First, the index (in a more complex form) permits total inequality to be decomposed into between-group inequality and within-group inequality. Second, although each measure satisfies the transfer principle, the Theil Index satisfies a much stronger transfer principle dependent only on the distance of the income transfer (Cowell, 1977, p. 65-71).

Atkinson Index. Atkinson (1970, 1983) argues that choosing among the Gini Coefficient, Coefficient of Variation and the Theil Index to make comparisons necessitates making a value judgement. If the Lorenz curves of two different groups do not cross, no problem arises because all of the measures will yield the same ranking. However, if the curves do intersect, the three measures may not yield the same ranking; i.e., one measure may show group A has less inequality than group B, while another measure may show just the opposite. Because value judgements are an integral part of evaluating inequality, Atkinson argues that such values should be explicitly considered. His approach is based on choosing a distributional parameter E, which is a crucial factor in the Atkinson Index:

$$A.I. = 1 - \sum_{i=1}^{n} \left[ (y_i/\bar{y})^{1-E} \right]^{1/(1-E)} \quad , E \neq 1.$$

E can have a value between zero and infinity, and the Atkinson Index increases as E increases. The Atkinson Index, however, always has a value between zero and one. (If E = 1, the above formula must be modified).

Interpreting E and choosing the "acceptable" value can be framed in terms of a mental experiment, although an E value between 0.5 and 2.0 is generally used (Atkinson, 1970, p. 58).

Data Description and Adjustments

The inequality measures discussed above are applied to 1984-85 faculty salary survey data from 23 midwestern universities with an average enrollment of 17,200 students. The survey data consists of average salaries for more than 80 disciplines at each faculty rank. For purposes of this study, some disciplines were excluded to make the discipline mix more comparable to that of the investigator's university. Average salaries for 53 disciplines at the ranks of full, associate and assistant professor were utilized. These 159 average salaries were based on the individual salaries of 12,420 faculty, which is 92 percent of the total faculty in the survey at the three ranks. Average salaries and number of faculty for full, associate, and assistant professors are, respectively: $37,476 (4841); $30,125 (4174); $24,752 (3405).

Salary inequality is understated if average discipline salaries are used rather than the salaries of individual faculty. At a given faculty rank, total salary variation about the mean is equal to the sum of the variation among disciplines and variations within disciplines. Therefore, using average discipline salaries to measure inequality ignores all inequality within disciplines. An analysis of associate professor salaries at the investigator's university revealed that approximately one-half of the total salary variation occurred within disciplines. In terms of the Coefficient of Variation, ignoring one-half of the total variation will yield a Coefficient of Variation which is about 40 percent below the true value.

Since survey data on individual salaries was not available, a salary distribution of individual salaries was created at each rank to add within-discipline variation. For each discipline at the assistant professor rank, the number of faculty in the discipline were distributed in equal numbers across a salary range between 90 and 110 percent of the discipline average. At the associate professor rank, a salary range of 87.5 to 112.5 percent of the discipline average salary was used; at the full professor level, the salary range was 85 to 115 percent. These salary ranges were chosen by first examining the salary distributions at each rank at the investigator's university. Salaries in the distributions were expressed as a percentage of the discipline average. Although the salary distributions were found to have a moderate triangular shape, a uniform distribution was used to distribute salaries within each discipline for computational ease. Ranges were chosen by requiring that approximately two-thirds of the observations fall within the range.

The procedures used to create the adjusted salary distributions of individual salaries are obviously inexact. However, a comparison of Coefficients of Variation at the associate professor rank between the discipline salary data and the adjusted salary data suggests the adjusted distributions are not unreasonable. The Coefficient of Variation for the adjusted distribution is 33 percent above the Coefficient of Variation for the discipline salary data. As mentioned above, a 40 percent difference would exist if within-discipline variation accounted for half of the total variation. Thus, it is likely the results presented in the next section for the adjusted salary distributions are on the low side, but close to the true values.

Salary Inequality - Results

Results from applying the four inequality measures to the survey data are shown in Table 1. "Discipline" results were obtained by using the average salaries for the 53 disciplines at each rank. "Adjusted" results are based on the adjusted salary distributions discussed in the previous section. It can be seen the measures indicate salary inequality is quite low in absolute terms. Across all ranks, the Gini Coefficient is 0.106 for discipline salaries and 0.116 for the adjusted salaries; the Coefficient of Variation has values of 0.187 and 0.204. Both the Theil Index and the Atkinson Index have very small values. (The Atkinson Index is computed by setting E equal to one). However, the typical pattern is for the Theil Index and Atkinson Index to have much lower values than the Gini Coefficient (Osberg, 1984, p. 27). For example, in 1973 the inequality indices (post tax) for the United States were: Gini = 0.369; Theil = 0.097; Atkinson (E = 0.5) = 0.113.

As would be expected, salary inequality within ranks is lower than the inequality for the combined ranks. However, salary inequality is highest for assistant professors. The Gini Coefficient for assistant professors (discipline salaries) is 0.062, while it is 0.038 and 0.041 for full and associate professors, respectively. Most new hires occur at the assistant professor rank, and therefore assistant professor salaries are more influenced by external market conditions and shifts in enrollment.

Obviously, the inequality indices have higher values when applied to the adjusted salary data. Further, the adjusted salary indices are significantly higher, on a percentage basis, at the three faculty

Table 1

Salary Inequality by Rank and Type of Measure - Discipline Salaries and Adjusted Salaries

| Measure/Salary Data | Professorial Rank | | | |
|---|---|---|---|---|
| | Assistant | Associate | Full | All[1] |
| Gini Coefficient | | | | |
| Discipline | 0.062 | 0.041 | 0.038 | 0.106 |
| Adjusted | 0.073 | 0.061 | 0.065 | 0.116 |
| Coefficient of Variation | | | | |
| Discipline | 0.119 | 0.083 | 0.076 | 0.187 |
| Adjusted | 0.134 | 0.111 | 0.117 | 0.204 |
| Theil's Index | | | | |
| Discipline | .0030 | .0015 | .0012 | .0076 |
| Adjusted | .0037 | .0026 | .0029 | .0090 |
| Atkinson Index (E=1) | | | | |
| Discipline | .0065 | .0032 | .0027 | .0177 |
| Adjusted | .0084 | .0059 | .0068 | .0207 |

[1]All ranks include only the ranks of full, associate and assistant professor.

ranks than for the combined ranks. This result is not unexpected. Within-discipline salary variations will result in a greater dispersion of salaries around rank means, than around the overall mean salary. Also, the adjusted salary results indicate smaller differences in inequality between the assistant rank and the other two ranks. For example, the Gini Coefficient is 0.073 for assistant professors and 0.065 for full professors when using the adjusted data; for the discipline data, the respective figures are 0.062 and 0.038. Given how the adjusted salary distributions were created, it is only possible to make tentative conclusions. But the results do suggest that assistant professor salary inequality is affected more by market conditions than by internal salary policies and seniority, while the opposite is the case for the other two ranks. The net effect results in more salary inequality at the assistant professor level than at the other two ranks, although the differences are not as large as indicated by the discipline salaries.

Salary inequality data for different professions, occupations and industries are not widely published. However, a comparison of the results in Table 1 with the limited data available suggests faculty salary inequality is no greater, and perhaps lower, than other occupations. The average Coefficient of Variation for wages in industries at the four digit Standard Industrial Classification code level is 0.213, which is slightly above the 0.204 value in Table 1 (Barsky & Personick, 1981). Gini Coefficients for broad classes of occupations and industries are within the range of 0.3 to 0.5 (Henle & Ryscavage, 1980). Although faculty salary inequality may not differ from other occupations, no normative conclusions can be made about

faculty salary inequality being "too high," "too low," or "just right." Differences in market conditions, unionization, skills, training and educational requirements among occupations preclude the making of normative statements. For example, an analysis of most measures of inequality indicates the United States is "among the more unequal" of OECD nations (Osberg, 1984, p. 29). Although income inequality in the United States may be relatively high, it cannot be argued from statistics alone that income "should be" redistributed.

Salary Redistribution

Inequality measures are most useful and least subject to interpretation problems when analyzing salary inequality of a single institution over time. Since the sensitivities of the measures differ, a comprehensive analysis should include the use of all four measures. There is no attempt here to thoroughly test the sensitivity of the measures. Rather, their sensitivities are demonstrated and compared by conducting a simple experiment with the adjusted salary data. Faculty salaries in the highest paying disciplines are increased 15 percent, and the salaries of other faculty are reduced 3.3% to fund the increase. High paying disciplines consist of business, engineering, computer science and law. The average salary of the high paying disciplines is $36,775, while the average salary of other faculty is $30,554. High paying disciplines account for 18.0% of the total salary dollars and for only 15.4% of all faculty. There are no interpretation problems with the results in Table 2. Although not shown, the Lorenz curves after redistribution lie entirely outside the initial Lorenz curves. The Lorenz curves and the inequality indices clearly indicate that salary inequality has increased. On a percentage basis the increases in the Theil and Atkinson Indices are about

Table 2

Salary Inequality by Rank and Type of Measure - Before and After Salary Redistribution

| | Professorial Rank | | | |
|---|---|---|---|---|
| Measure/Salary Data | Assistant | Associate | Full | All |
| Gini Coefficient | | | | |
| Before | 0.073 | 0.061 | 0.065 | 0.116 |
| After | 0.102 | 0.086 | 0.087 | 0.133 |
| Coefficient of Variation | | | | |
| Before | 0.134 | 0.111 | 0.117 | 0.204 |
| After | 0.204 | 0.170 | 0.166 | 0.240 |
| Theil's Index | | | | |
| Before | .0037 | .0026 | .0029 | .0090 |
| After | .0084 | .0058 | .0056 | .0121 |
| Atkinson Index (E=1) | | | | |
| Before | .0084 | .0059 | .0068 | .0207 |
| After | .0179 | .0125 | .0124 | .0272 |

twice those of the other measures. Also, as expected, salary inequality within ranks increased more than inequality for the combined ranks.

In recent years, salaries of the market driven disciplines probably increased relative to other faculty salaries by less than the 18.3% (15% + 3.3%) used in the experiment. For example, between 1979 and 1985 business faculty salaries increased 10 percent relative to all faculty salaries, about half of the percentage increase used in the experiment. Nonetheless, it is obvious from the results in Table 2 that the inequality indices would also be sensitive to even smaller salary redistributions.

## Salary Equality Between Groups

### Measures

The inequality measures discussed thus far are not adequate single measures of inequality between groups. Measures are needed which quantify how closely the salary distribution of the minority group fits the salary distribution of the majority group. If the two distributions have a perfect fit (perfect equality), it can be assumed minority faculty are distributed across disciplines, ranks, years of seniority and performance levels in the same proportions as the majority faculty. Perfect equality may not be achievable, or perhaps not even desired by the minority group, but it can serve as base for measurement purposes.

In this analysis, two inequality measures are used to describe the salary inequality between female and male faculty. One reason female salaries are lower, is because female faculty are over represented in the lower paying disciplines, just as women dominate lower paying occupations in the United States (Rytina, 1982a). Over half of the salary differential between female and male faculty is due to women being over represented in low paying disciplines. Another reason for female salaries being lower is

because female faculty tend to have fewer years than males at their current rank; less seniority is also the case for women for many other occupations (Rytina, 1982b).

An inequality measure proposed by Gastwirth (1975) is the PROB measure, which is related to the Mann-Whitney form of the Wilcoxon test. The PROB measure gives the probability that a randomly selected woman earns at least as much as a randomly chosen man. PROB can be expressed in terms of the female cumulative salary distribution $F(x)$ and the male salary distribution $g(x)$ as:

$$\text{PROB} = \sum_{o}^{x} (1-F(x))g(x).$$

Since the perfect equality value of PROB is 0.5, Gastwirth uses twice the value of PROB (TPROB) as the measure, so perfect equality has a value of 1.0.

Another possible measure can be called "Differences in Cumulative Percentages" (DCP), which pictorially is somewhat similar to the Lorenz Curve and Gini Coefficient. In Figure 1, the cumulative percentage of total male salary dollars would be plotted on the horizontal axis, and the cumulative percentage of total female salary dollars would be on the vertical axis. The cumulative percentages are calculated after ranking individual observations from low to high salary. Typically, the DCP curve lies above the diagonal line AB because of female faculty being over represented in the lower part of the salary distribution. As for the Lorenz Curve, the area between the curve and the diagonal line is divided by the area ABD (refer to Figure 1) to calculate a Female Coefficient, which is similar to a Gini Coefficient. The DCP Index is computed by subtracting the Female Coefficient from one to make the DCP Index

comparable to TPROB. Unlike the Lorenz Curve, the DCP Curve can cross the diagonal line. If the curve does cross the diagonal, a Male Coefficient is computed relative to the area ABC, and some proportion of the Male Coefficient is substracted from the Female Coefficient. The proportion used would depend on an institution's attitude about between-group inequality at different points of the salary distribution. In the analysis below, the DCP curves do not cross the diagonal line.

Results

The TPROB and DCP Index measures were applied against 1984-85 data taken from the salary survey previously mentioned. Data are average male and female salaries for each discipline and rank. Although using discipline average salaries ignores within-discipline inequality, the results shown in Table 3 may not be very biased.

Table 3

TPROB and DCP Indices of Inequality by Rank

| | Professorial Rank | | | |
|---|---|---|---|---|
| Measure/Salary Data | Assistant | Associate | Full | All |
| TPROB | 0.647 | 0.529 | 0.293 | 0.471 |
| DCP Index | 0.659 | 0.568 | 0.317 | 0.435 |

Significant bias exists only if within discipline variation for female faculty is significantly different from male faculty. Both the TPROB and DCP Index indicate inequality increases with rank; the TPROB measure for full professors is less than half the value for assistant professors. Affirmative action, changing attitudes and career aspirations, and market

forces have had the greatest impact at the assistant and associate professor ranks. But full professor inequality will be reduced as current female faculty progress through the ranks. In 1984-85, 18 percent of the assistant professors in high paying disciplines was female, but female faculty accounted for only 3 percent at the full professor level. Salary inequality between male and female faculty is approximately the same as inequality between males and females in other occupations. The TPROB value for workers from all industries was 0.464 in 1972, which is nearly equal to the 0.471 value for the combined ranks (Gastwirth, 1975).

Results in Table 2 reflect the inequality due to discipline mix and lower female salaries within disciplines. Inequality due to discipline mix alone can be calculated by using the discipline average salary in place of the female and male averages. The TPROB and DCP Index for the combined ranks were 0.586 and 0.565, respectively, when using the same average salary for both female and male faculty. Therefore, lower female salaries within disciplines causes TPROB to decline from 0.586 to 0.471, and the DCP Index to decline from 0.565 to 0.459. It is evident from these results that the over representation of female faculty in the lower paying disciplines accounts for most of the inequality.

## Summary and Conclusions

Researchers need comprehensive measures of salary inequality to quantity inequality among all faculty and inequality between faculty groups. Issues such as salary adjustment for market sensitive disciplines and female-male salary inequality necessitate the annual assessment of salary inequality. The Gini Coefficient, Coefficient of Variation, Theil Index and Atkinson Index are as effective in measuring salary inequality among faculty as in measuring a country's income inequality. The measures

differ regarding their sensitivities to changes in different parts of the salary distribution, and the measures can provide conflicting results when making comparisons. Therefore, a thorough analysis requires using each of the four measures, including the more complex Theil and Atkinson Indices. Between-group measures of salary inequality have not been as fully explored in the literature. Nonetheless, the TPROB measure and DCP Index appear to be effective.

Applying the six inequality measures to 1984-85 salary survey data yields the following conclusions:

1) In terms of absolute values, the measures indicate faculty salary inequality is very low. However, when compared against limited data, it can only be concluded that salary inequality among faculty is no greater than inequality in other occupations;
2) Salary inequality is highest for assistant professors and lowest for full professors. Results suggest assistant professor inequality is affected more by market conditions than by internal salary policies, while the opposite is the case for higher ranks;
3) Salary inequality between female and male faculty is lowest for assistant professors and highest for full professors. The over representation of female faculty in the lowest paying disciplines accounts for most of the inequality;
4) Salary inequality between female and male faculty is approximately the same as female-male inequality in all other occupations.

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